The Defense Acquisition Process (DoD 5000) and the Cost Estimating Process

Chapter 2

Chapter 2

- **The DoD 5000 Acquisition process**
- **The Life Cycle Cost Estimating (LCCE) Process**
  - **Definition and Planning**
  - **Data Collection**
  - **Estimate Formulation**
  - **Risk and Uncertainty analyses**
  - **Documentation, Review and presentation**

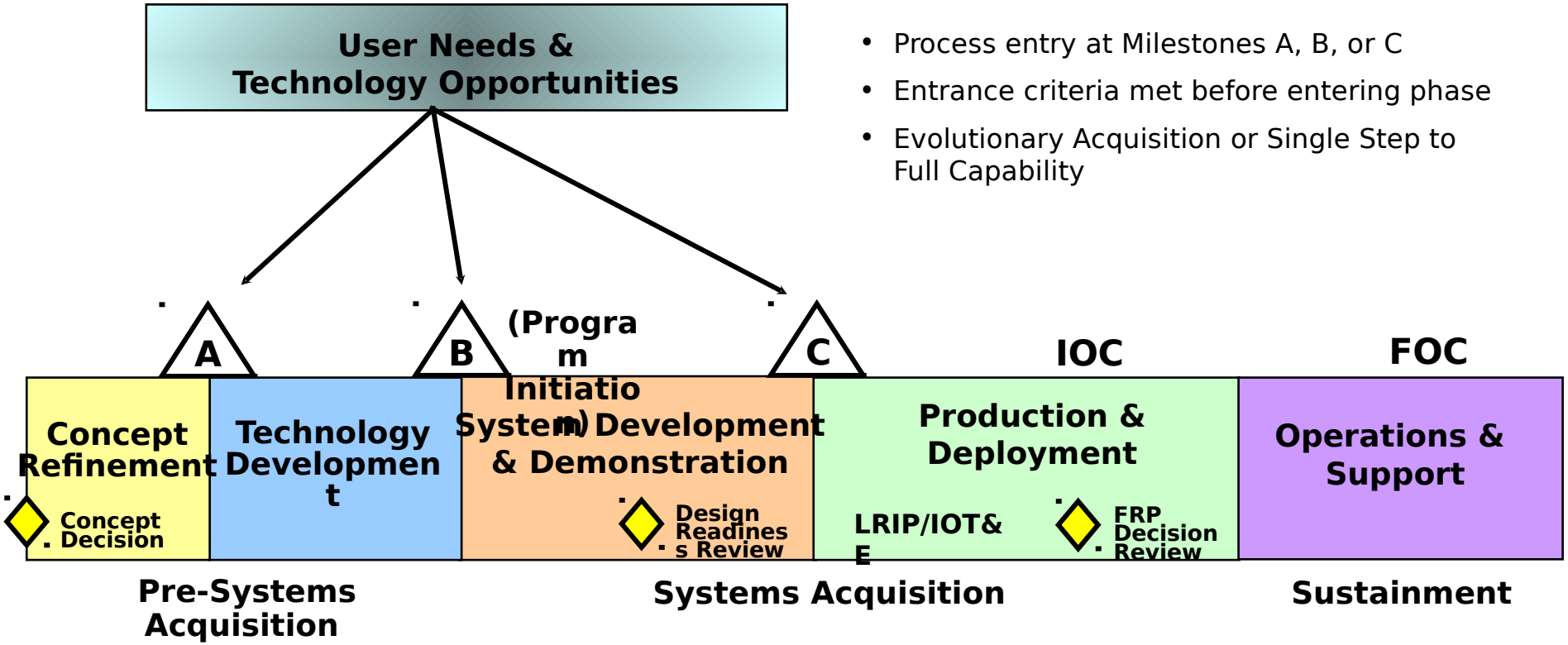
The DoD Acquisition Process

- **Specifics contained in several directives, e.g.,**
  - **DODD 5000.1 “The Defense Acquisition System”**
  - **DODI 5000.2 “Operation of the Defense Acquisition System”**
  - **DOD 5000.4-M “ Cost Analysis Guidance and Procedures”**

- **These directives provide a disciplined approach to integrating the acquisition process with Requirements generation, and the Planning, Programming, Budgeting and Execution System (PPBES) processes**

- **Acquisition Milestone Process = DoD’s implementation of these directives**
  - **http://akss.dau.mil/darc/TERMS/index.htm**

Acquisition Milestone Process: The DoD 5000 Model

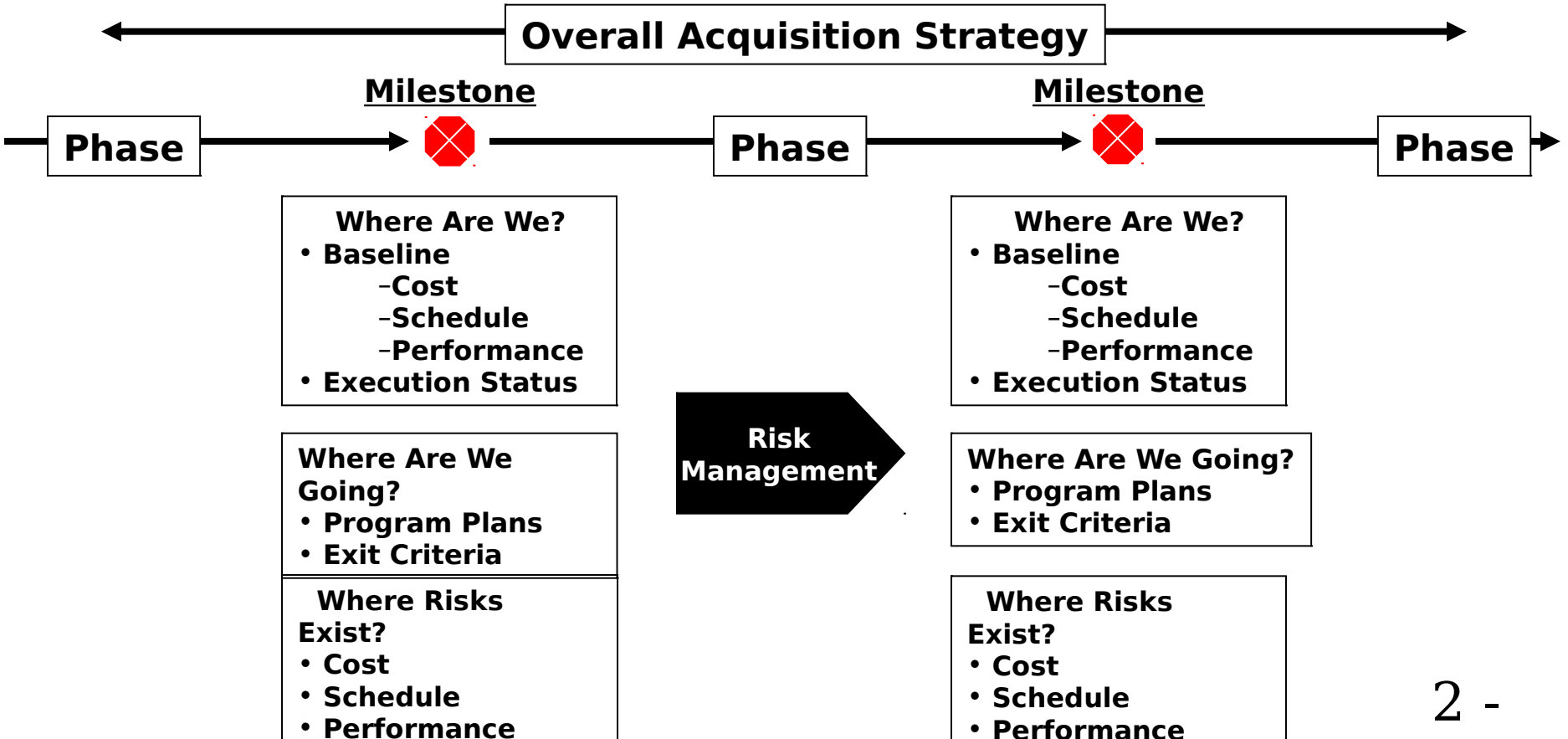


- Process entry at Milestones A, B, or C
- Entrance criteria met before entering phase
- Evolutionary Acquisition or Single Step to Full Capability

Acquisition Milestone Process

- **Separates program life cycle into 3 milestones and 3 phases**
  - ***Essentially a risk management tool***

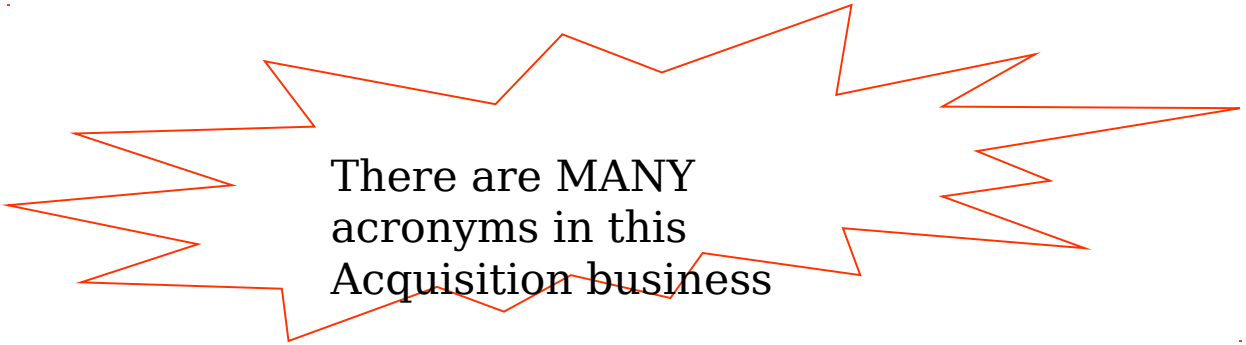
Acquisition Phases and Milestone Decision Points



Acquisition Categories

- **A technology project or acquisition program is categorized based on its location in the acquisition process, dollar value, and complexity.**

- **Pre-ACAT Technology Projects**
  - **The USD(AT&L) is the MDA for those projects that, if successful, will likely result in an MDAP. The USD (NII) is the MDA for those projects that, if successful, will result in a MAIS.**



Acquisition Categories

Category	Criteria (FY00$)	Designation Authority	Milestone Decision Authority
ID MDAP	> $365M RDTE or > $2.19B Proc or so designated by USD(AT&L)	USD(AT&L)	USD(AT&L)
IC MDAP	same	USD(AT&L)	ASN(RD&A)
IAM MAIS	> $378M Lifecycle > $126M Proc > $31.5M Single Year	ASD(C3I)	USD (NII)
IAC MAIS	same	ASD(C3I)	ASN(RD&A)

Acquisition Categories

Category	Criteria (FY00$)	Designation Authority	Milestone Decision Authority
II Major System	> $140M RDTE or > $660M Proc or so designated by ASN(RD&A)	ASN(RD&A)	ASN(RD&A)
III	Less than major acquisition programs	ASN(RD&A)	SYSCOM/PEO/ DRPM as designated

Life-Cycle Cost (LCC) Phases

- **Research &Development (R&D): Estimated cost of all program specific research and development.**
- **Investment: Estimated cost of the investment phase, including total cost of procuring the prime equipment; related support equipment; training; initial and war reserve spares; pre-planned product improvements and military construction.**
- **Operating and Support (O&S): Estimated cost of operating and supporting the fielded system, including all direct and indirect costs incurred in using the system, e.g., personnel, maintenance (unit and depot), and sustaining investment (replenishment spares). The bulk of life-cycle costs occur in this category.**
- **Disposal: Estimated cost to dispose of the system after its useful life. This includes demilitarization, detoxification, long-term waste storage, environmental restoration and related costs.**

These are categories commonly used by the Cost Analysis Improvement Group (CAIG). They are listed in DoD 5000.4-M, Cost Analysis Guidance and Procedures.

LCC Categories

- **Development Cost is the cost of all research- and development-related activities, contract and in-house, necessary to design and test the system. It includes a number of WBS elements, including Prime Mission Equipment, Support Equipment, Training, etc. Prototypes and test articles are included in this cost category. Development costs are funded with only the RDT&E appropriation and are included only in the R&D cost category.**

- **Flyaway Cost (Rollaway, Sailaway, etc.) refers to the cost of procuring prime mission equipment (e.g., an aircraft, ship, tank, etc.). It is funded with Procurement appropriations and is part of the Investment cost category. Figure 1 shows that this term includes the WBS elements of Prime Mission Equipment, System Engineering/Program Management, System Test and Evaluation, Warranties, and Engineering Changes. (Note: DoD 5000.4-M defines flyaway cost as being funded out of the RDT&E and Procurement appropriations, but this has been changed – flyaway cost is funded only by the Procurement appropriation. The new policy will be incorporated in a future revision to DoD 5000.4-M.)**

- **Weapon System Cost is funded completely from the Procurement appropriations. It is the procurement counterpart of Development Cost in that it contains the same WBS elements as Development Cost. Weapon System Cost consists of the Flyaway Cost plus the additional WBS elements shown in Figure 1.**

- **Procurement Cost is also funded completely from the Procurement appropriations. It includes Weapon System Cost plus the WBS element of initial spares. For Navy shipbuilding programs, outfitting and post-delivery costs are also included when these costs are Procurement-funded.**

LCC Categories (con't)

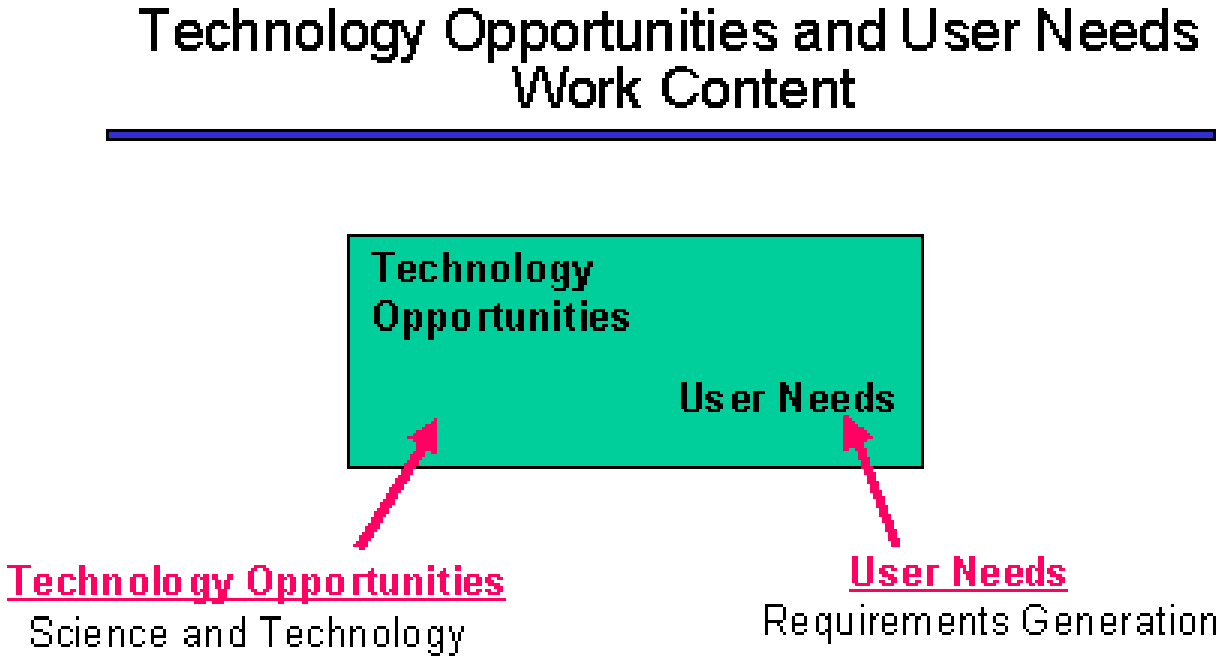
- **Program Acquisition Cost is a multi-appropriation cost. It consists of all costs associated with developing, procuring and housing a weapon system. Because it consolidates development, procurement and military construction costs, RDT&E, Procurement and MILCON appropriations are included. This is the complete cost of acquiring a weapon system - ready to operate.**

- **Operating and Support Costs are funded primarily with the O&M and Military Personnel appropriations. However, RDT&E, Procurement, and/or MILCON appropriations may also be used, as appropriate, based on the nature of the effort, after the weapon system has been deployed. This category includes all costs for personnel, equipment, and supplies associated with operating, modifying, maintaining and supporting a weapon system in the DoD inventory. This includes all direct and indirect costs. These costs do not include any of the development costs, procurement costs or any other part of the program acquisition costs for the weapon system, nor do they include any disposal costs for the weapon system. Because the system is already fielded, the MIL-HDBK 881B WBS does not apply to this cost term.**

- **Life-Cycle Cost includes all WBS elements, all appropriations, and all cost categories. It is the sum of Program Acquisition Cost, Operating and Support Cost, and Disposal Cost for a system.**

Pre-Systems Acquisition

- **Pre-system acquisition is composed of ongoing activities in development of user needs, in science and technology, and in concept development work specific to the development of a material solution to an identified, validated need.**



User Needs Activities

- **The Initial Capability Requirements document (ICRD) shall identify and describe the projected mission needs of the user in the context of the threat to be countered or business need to be met.**
- **In the process of refining requirements, the user shall adhere to the following key concepts:**
  - **Keep all reasonable options open.**
  - **Avoid early commitments to system-specific solutions.**
  - **Define requirements in broad operational capability terms.**
  - **Develop time-phased requirements with objectives and thresholds.**
  - **Consider changing performance requirements to facilitate COTS/NDI solutions.**
  - **Evaluate survivability in anticipated threat environment.**
  - **Address *COST* in the Operational Requirements Document (ORD) in terms of a threshold and objective.**

FIX MNS TO ICRD

Material Acquisition Requirement Questions

- **Before proposing a new acquisition program, DoD components shall affirmatively answer the following questions:**
  - **Does the acquisition support core or priority mission functions that need to be performed by the Federal Government?**
  - **Are there no alternative private sector or government sources that can better perform the function?**

Technological Opportunity Activities

- **Technological opportunities within DoD laboratories and research centers, from academia, or from commercial sources are identified within the Defense Science and Technology (S&T) Program.**
- **The DoD S&T Program mission is to provide the users of today and tomorrow with superior and affordable technology to support their missions, and to enable them to have revolutionary war-winning capabilities.**
- **The S&T Program is uniquely positioned to reduce the risks of promising technologies before they are assumed in the acquisition process.**

Science & Technology Program

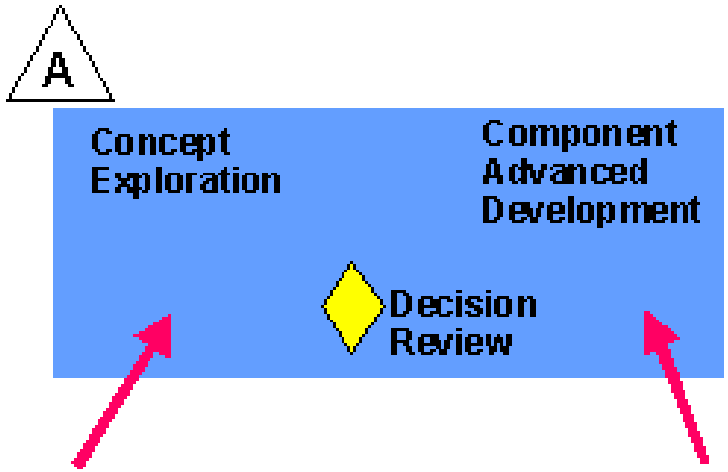
- **The S&T Program consists of the following:**
  - ***Basic Research. (6.0)***
    - » **Scientific study and experimentation directed toward increasing knowledge and understanding in the science fields and discovering phenomena that can be exploited for military purposes.**
  - ***Applied Research. (6.1)***
    - » **Translates promising research into solutions for broadly defined military problems with effort that may vary from applied research to sophisticated breadboard subsystems that establish the initial feasibility and practicality of proposed solutions or technologies.**
  - ***Advanced Technology. (6.2)***
    - » **Demonstrates the performance payoff, increased logistics or interoperability capabilities, or cost reduction potential of militarily relevant technology.**

Technology Transition Mechanisms

- **To ensure the transition of innovative concepts and superior technology to the user and acquisition customer, the DoD Component S&T Executives shall use three mechanisms:**
  - ***Advanced Technology Demonstrations (ATDs).***
    - » **Used to demonstrate the maturity and potential of advanced technologies for enhanced military operational capability or cost effectiveness.**
  - ***Advanced Concept Technology Demonstrations (ACTDs).***
    - » **Used to determine military utility of proven technology and to develop the concept of operations that will optimize effectiveness.**
  - ***Experiments.***
    - » **Used to develop and assess concept-based hypotheses to identify and recommend the best value-added solutions for changes to doctrine, organizational structure, training and education, materiel, leadership, and people required to achieve significant advances in future joint operational capabilities.**

Concept & Technology Development

Concept and Technology Development Work Content



Concept Exploration

- Paper studies of alternative concepts for meeting a need

Component Advanced Development

- Development of subsystems/components that must be demonstrated before integration into a system
- Concept/tech demonstration of new system concept(s)

Concept & Technology Development

- **This path into systems acquisition begins with examining alternative concepts, including cooperative opportunities and procurement or modification of Allied systems or equipment, to meet a stated mission need.**
- **Begins with a decision to enter Concept and Technology Development at Milestone A.**
- **Ends with a selection of a system architecture(s) and the completion of entrance criteria for Milestone B and System Development and Demonstration Phase.**

Concept & Technology Development

- **Entrance Criteria**
  - **After the requirements authority validates and approves a MNS, the MDA will review the MNS, consider possible technology issues, and identify possible alternatives before making a Milestone A decision.**
  - **The decision shall not be made final until a thorough analysis of multiple concepts to be studied, including international systems from Allies and cooperative opportunities has been completed.**
  - **If an international system is selected, the program shall enter systems acquisition activities at Milestone B or C.**

Concept & Technology Development

- **Milestone A**
  - **At Milestone A, the MDA shall approve the initiation of concept studies, designate a lead Component, approve Concept Exploration exit criteria, and issue the Acquisition Decision Memorandum.**
  - **The leader of the concept development team, working with the integrated test team, shall develop an evaluation strategy that describes how the capabilities in the MNS will be evaluated once the system is developed.**
  - **A favorable Milestone A decision *Does Not* yet mean that a new acquisition program has been initiated.**
  - **Milestone A approval can lead to Concept Exploration or Component Advanced Development depending on whether an evaluation of multiple concepts is desired or if a concept has been chosen, but more work is needed on key sub-systems or components before a system architecture can be determined and the technologies can be demonstrated in a relevant environment.**

Concept & Technology Development

- **Concept Exploration**
  - **Typically consists of competitive, parallel, short-term concept studies. The focus is to define and evaluate the feasibility of alternative concepts and to provide a basis for assessing the relative merits of these concepts.**
  - **Analyses of alternatives shall be used to facilitate comparisons of alternative concepts.**
  - **Emphasis will be placed on innovation and competition.**
  - **The most promising system concepts shall be defined in terms of:**
    - » **initial, broad objectives for cost, schedule, and performance;**
    - » **identification of interoperability, security, survivability, operational continuity, technology protection, operational support, and infrastructure requirements within a family of systems;**
    - » **opportunities for tradeoffs, and an overall acquisition strategy and test and evaluation strategy.**

Concept & Technology Development

- **Component Advanced Development**
  - **The project shall enter Component Advanced Development when the project leader has a concept for the needed capability, but does not yet know the system architecture.**
  - **Unless otherwise determined by the MDA, the component technology to be developed shall have been proven in concept.**
  - **The project shall exit Component Advanced Development when a system architecture has been developed and the component technology has been demonstrated in the relevant environment or the MDA decides to end this effort.**
  - **This effort is intended to reduce risk on components and subsystems that have only been demonstrated in a laboratory environment and to determine the appropriate set of subsystems to be integrated into a full system.**
  - **This effort is normally followed by entry into the System Development and Demonstration phase after a Milestone B decision by the MDA.**

Systems Acquisition

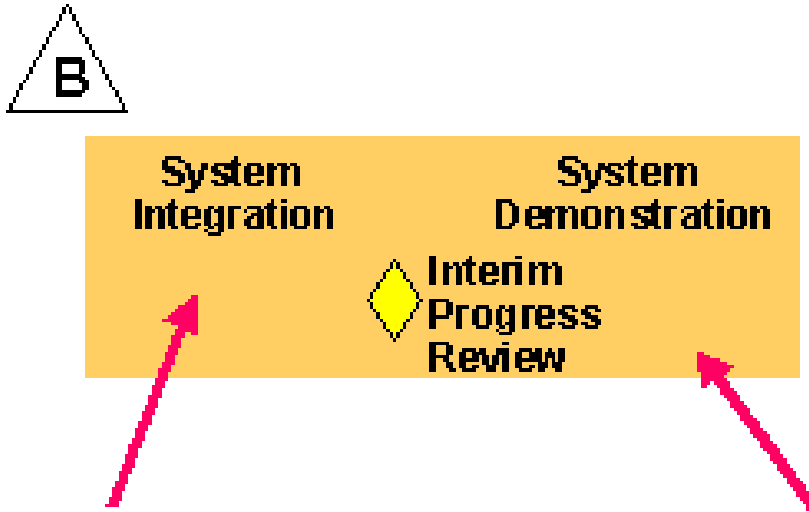
- **Systems acquisition is the process of developing concepts into producible and deployable products that provide capability to the user, based on an analysis of alternative ways to meet the military need.**
- **The goal is to develop the best overall value solution over the system's life cycle that meets the user's operational requirements.**
- **Generally, use or modification of systems or equipment that the DoD Components already own is more cost and schedule-effective than acquiring new materiel.**

Systems Acquisition

- **If existing U.S. military systems or other on-hand materiel cannot be economically used or modified to meet the operational requirement, an acquisition program may be justified and acquisition decision-makers shall follow the following hierarchy of alternatives:**
  - **the procurement (including modification) of commercially available domestic or international technologies, systems or equipment, or the additional production (including modification) of previously-developed U.S. military systems or equipment, or Allied systems or equipment;**
  - **cooperative development program with one or more Allied nations;**
  - **new joint development program;**
  - **and a new Component-unique development program.**

System Development & Demonstration

System Development and Demonstration Work Content



System Integration

- System Integration of subsystems and components
- Reduction of integration risk

System Demonstration

- Complete development
- Demonstrate engineering development models

System Development & Demonstration

- **The purpose of the System Development and Demonstration phase is to develop a system, reduce program risk, ensure operational supportability, design for producibility, ensure affordability, ensure protection of Critical Program Information, and demonstrate system integration, interoperability, and utility.**
- **This phase can be entered either directly out of technology opportunity and user need activities or from Concept Exploration.**
- **The actual entry point depends on the maturity of the technologies, validated requirements (including urgency of need), and affordability.**

System Development & Demonstration

- **Entrance Criteria**
  - **Entrance into System Development and Demonstration is dependent on three things:**
    - **technology (including software) maturity,**
    - **validated requirements, and**
    - **funding.**
  - **Technology is developed in S&T or procured from industry. Technology must have been demonstrated in a relevant environment or, preferably, in an operational environment to be considered mature enough to use for product development in systems integration.**
  - **Transition into System Development and Demonstration also requires full funding (i.e., inclusion in the budget and out-year program of the funding for all current and future efforts necessary to carry out the acquisition strategy).**

System Development & Demonstration

- **Milestone B**
  - **Milestone B is normally the initiation of an acquisition program. The purpose of Milestone B is to authorize entry into System Development and Demonstration.**
- **Approval Considerations:**
  - **Validated ORD**
  - **System Threat Assessment**
  - **Independent Technology Assessment**
  - **Analysis of Alternatives**
  - **Independent Cost Estimate**
  - **Economic Analysis**
  - **Manpower Estimate**
  - **System affordability and funding**
  - **Proposed acquisition strategy**

System Development & Demonstration

- **Acquisition Strategy Considerations:**
  - **The acquisition strategy shall define not only the approach to be followed in System Development and Demonstration, but also how the program is structured to achieve full capability.**
  - **There are two such approaches, *evolutionary* and *single step* to full capability.**
  - **An *evolutionary* approach is preferred.**
  - ***Evolutionary* acquisition is an approach that fields an operationally useful and supportable capability in as short a time as possible.**
  - ***Evolutionary* acquisition delivers an initial capability with the explicit intent of delivering improved or updated capability in the future.**

System Development & Demonstration

- **Acquisition Strategy Considerations:**
  - **In a *single step* to full capability approach, the full system capability is developed and demonstrated prior to Milestone C.**
  - **Under this approach, any modification that is of sufficient cost and complexity that it could itself qualify as an MDAP or MAIS shall be considered for management purposes as a separate acquisition effort.**

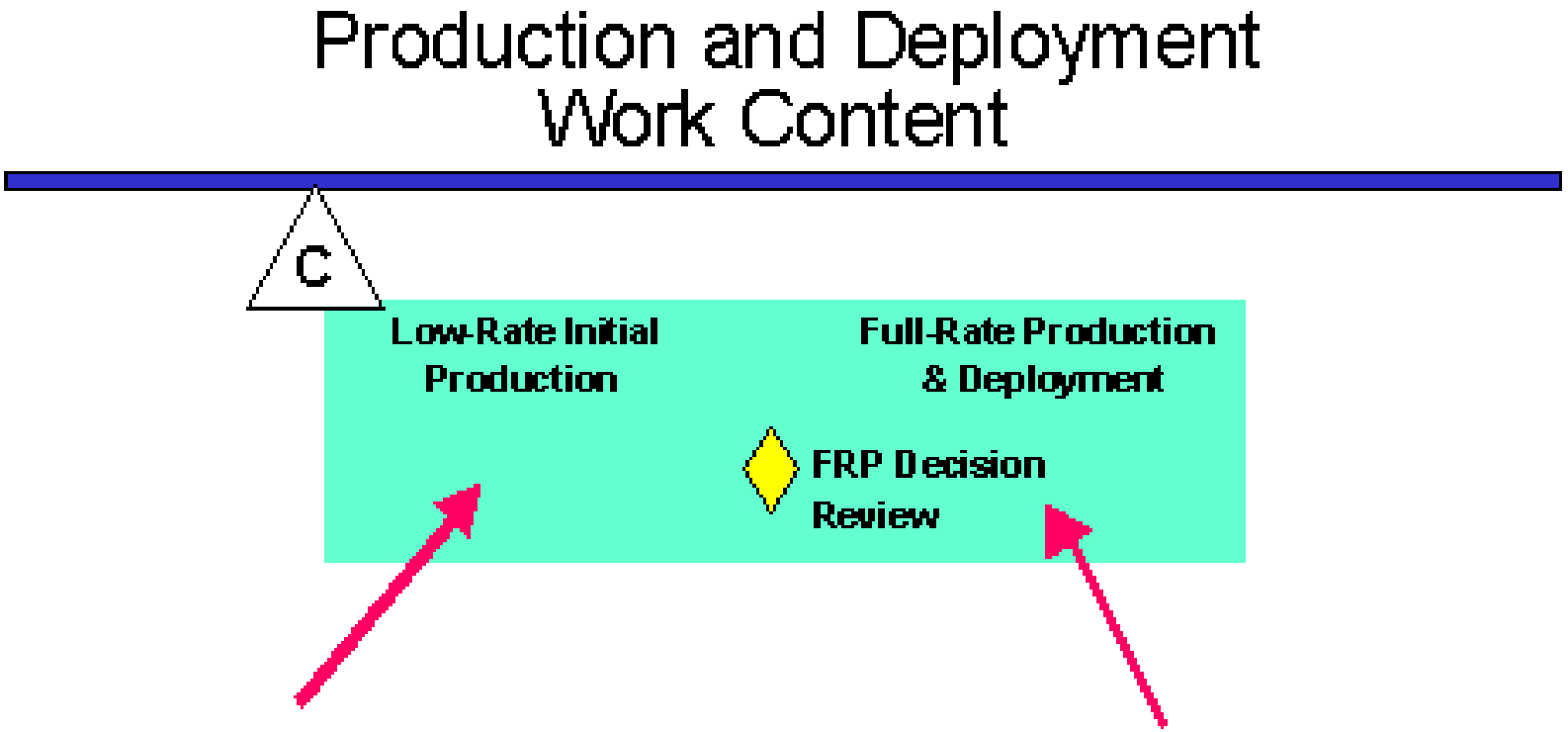
System Development & Demonstration

- **Milestone B approval can lead to *System Integration* or *System Demonstration*.**
- ***System Integration***
  - **The program shall enter System Integration when the PM has an architecture for the system, but has not yet integrated the subsystems into a complete system. The program shall exit System Integration when the integration of the system has been demonstrated in a relevant environment using prototypes (e.g., first flight, interoperable data flow across systems), a system configuration has been documented, the MDA determines a factor other than technology justifies forward progress, or the MDA decides to end this effort.**
  - **This effort is intended to integrate the subsystems and reduce system-level risk.**

System Development & Demonstration

- ***System Demonstration***
  - **The program shall enter *System Demonstration* when the PM has demonstrated the system in prototype articles.**
  - **This effort is intended to demonstrate the ability of the system to operate in a useful way consistent with the validated ORD.**
  - **This phase ends when a system is demonstrated in its intended environment, using engineering development models or integrated commercial items; meets validated requirements; industrial capabilities are reasonably available; and the system meets or exceeds exit criteria and Milestone C entrance requirements.**

Production and Deployment



Low-Rate Initial Production

- IOT&E, LFT&E of production-representative articles
- Establish full manufacturing capability
- Execute low-rate production

Full-Rate Production & Deployment

- Execute full rate production
- Deploy system

Production and Deployment

- **The purpose of the Production and Deployment phase is to achieve an operational capability that satisfies mission needs.**
- **A system must be demonstrated before the Department of Defense will commit to production (or procurement) and deployment.**
- **The MDA shall make the commitment decision at Milestone C.**
- **Milestone C can be reached directly from pre-systems acquisition (e.g., a commercial product) or from System Development and Demonstration phase.**

Production and Deployment

- **Entrance Criteria**
  - **Regardless of the entry point, approval at Milestone C is dependent on the following criteria being met:**
    - » **Technology maturity**
    - » **System and relevant mission area architectures**
    - » **Mature software capability**
    - » **Demonstrated system integration or demonstrated commercial products in a relevant environment, and**
    - » **No significant manufacturing risks.**
  - **Other criteria include:**
    - » **An approved ORD.**
    - » **Acceptable interoperability.**
    - » **Acceptable operational supportability.**
    - » **Compliance with the DoD Strategic Plan.**
    - » **Demonstration that the system is affordable throughout the life cycle, optimally funded, and properly phased for rapid acquisition.**

Production and Deployment

- **Milestone C**
  - **The purpose of this milestone is to authorize entry into low-rate initial production (for MDAPs and major systems), into production or procurement (for non-major systems that do not require low-rate production) or into limited deployment for MAIS or software-intensive systems with no production components.**
- **Approval Considerations:**
  - **Independent Cost Estimate**
  - **Economic Analysis**
  - **Manpower Estimate**
  - **Acquisition Strategy**
  - **Exit criteria for low rate initial production**
- **A favorable Milestone C decision authorizes the PM to commence LRIP or limited deployment for MDAPs and major systems.**

Production and Deployment

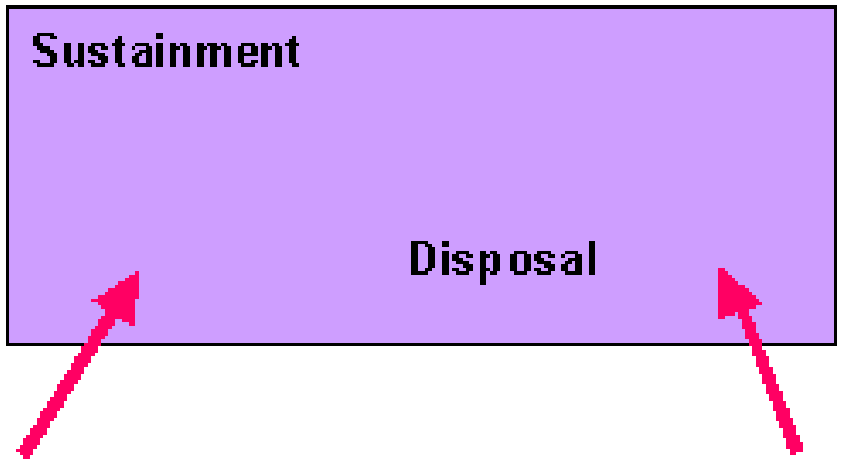
- **Low Rate Initial Production (LRIP)**
  - **This work effort is intended to result in completion of manufacturing development in order to:**
    - » **ensure adequate and efficient manufacturing capability,**
    - » **produce the minimum quantity necessary to provide production configured or representative articles for initial operational test and evaluation (IOT&E),**
    - » **establish an initial production base for the system,**
    - » **permit an orderly increase in the production rate for the system, sufficient to lead to full-rate production upon successful completion of operational (and live-fire, where applicable) testing.**

Production and Deployment

- **Full Rate Production (FRP)**
  - **Before making the FRP decision, the MDA shall consider:**
    - » **Independent Cost Estimate**
    - » **Manpower Estimate**
    - » **Results of OT&E**

Sustainment

Operations and Support Work Content



Sustainment

- Operational support

Disposal

- Demilitarization
- Disposal

Sustainment

- **The objectives of this activity are the execution of a support program that meets operational support performance requirements and sustainment of systems in the most cost-effective manner for the life cycle of the system.**
- **The scope of support generally includes:**
  - **Supply support**
  - **Maintenance**
  - **Transportation**
  - **Sustaining Engineering**
  - **Data management**
  - **Configuration management**
  - **Manpower, personnel, training,**
  - **Etc…**

Sustainment

- **When the system has reached the end of its useful life, it must be disposed of in an appropriate manner.**
- **The PM shall address disposal in the acquisition strategy.**

Chapter 2

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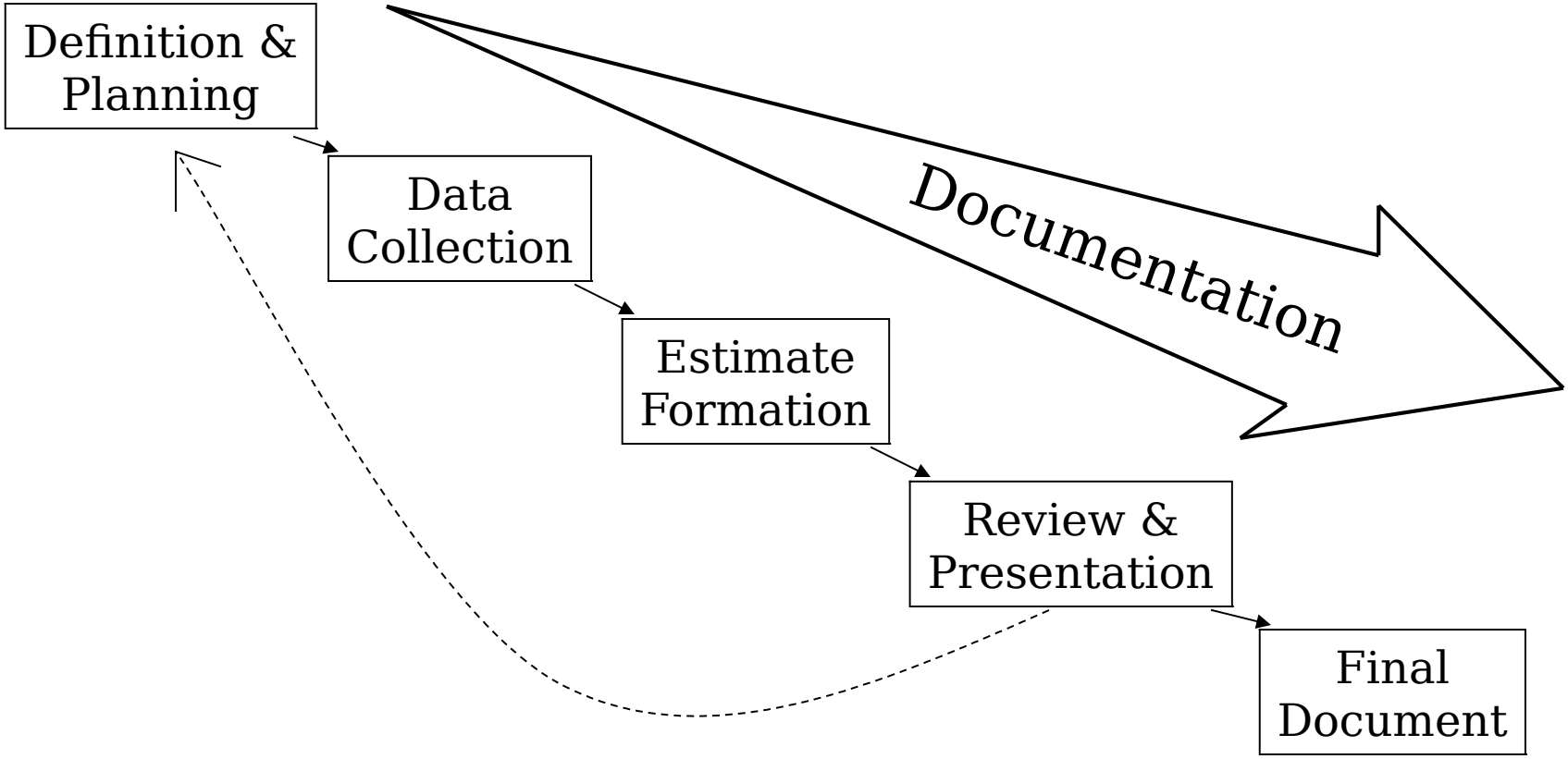
- **The Life Cycle Cost Estimating (LCCE) Process**
  - **Definition and Planning**
  - **Data Collection**
  - **Estimate Formulation**
  - **Risk and Uncertainty analyses**
  - **Documentation, Review and presentation**

The Cost Estimating Process

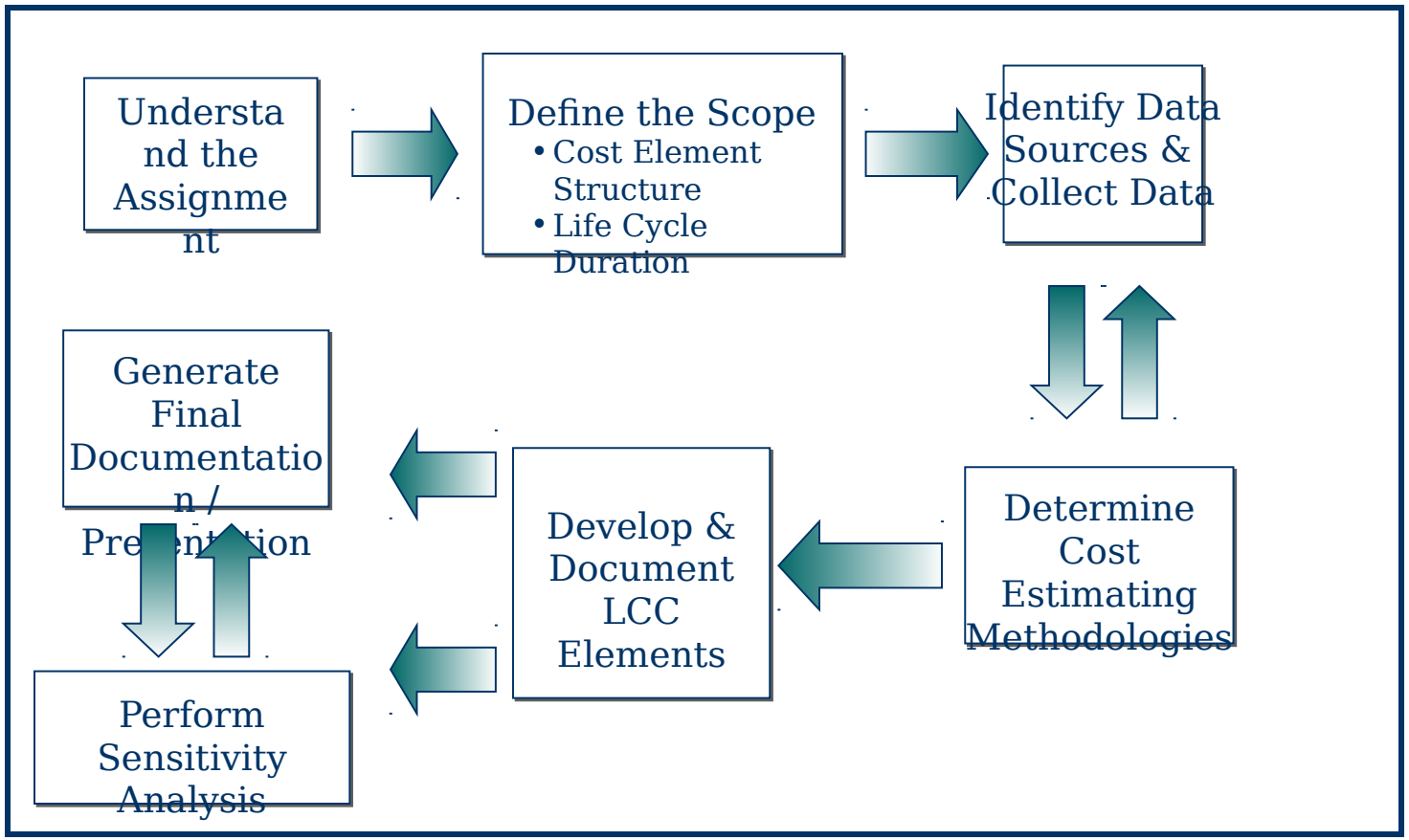
- **What do we need in order to develop a cost estimate?**
  - **Description of Activity (CARD, WBS, CES)**
  - **History (Data, VAMOSC)**
  - **Tools (CERs, LCs, Inflation Factors)**
  - **Technical Experts**
  - **Medium (Spreadsheet, ACEIT, PACER)**
  - **Documentation**

The Cost Estimating Process



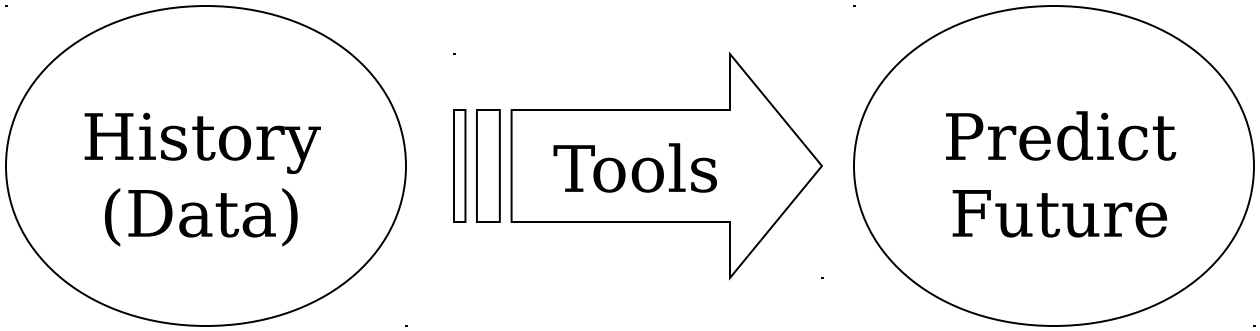
As with any scientific undertaking, there is a repeatable process at the

LCCE Process



The Cost Estimating Process

- **Estimates are always based on history…otherwise, they are mere guesses.**



- **We use the tools to make the historical data look as much as possible like the future system.**

The Cost Estimating Process

- **Definition and Planning**
  - **Knowing the Purpose of the Estimate**
  - **Defining the System**
  - **Ground Rules and Assumptions**
  - **Selecting the Estimating Approach**
  - **Putting the Team Together**

The Cost Estimating Process

- Knowing the Purpose of the Estimate
- What will the estimate be used for?
  - The Purpose dictates:
    - The Scope of the Estimate
    - Amount of Time it will take
    - Level of Detail
    - Estimating Techniques
    - Type of Documentation Required

The Cost Estimating Process

- **There are two basic reasons for a Cost Estimate:**
  - **Budget Formulation**
  - **Comparative Studies**

The Cost Estimating Process

- **Types of Estimates associated with Budget Formulation**
  - **Program Office Estimates**
  - **Component Cost Analyses**
  - **Independent Cost Estimates**
  - **What-If Exercises**
  - **Feasibility Studies**

The Cost Estimating Process

- **Comparative Studies**
  - **A Process of making Cost and Benefit Comparisons among Alternatives**

The Cost Estimating Process

- **Types of Estimates associated with Comparative Studies**
  - **Economic Analyses**
  - **Analyses of Alternatives (formerly COEAs)**
  - **Force Structure Analyses**
  - **Tradeoff Studies**
  - **Source Selections**
  - **Privatizations**
  - **Base Closures**

The Cost Estimating Process

- **Program Office Estimate**
  - **Program Manager's estimate of the resources required for his program**
- **Baseline Cost Estimate**
  - **Usually the first estimate done on an acquisition program**
  - **Done prior to Phase II (EMD Phase)**
  - **Later on, it measures program cost growth**

The Cost Estimating Process

- **Component Cost Analysis**
  - **Prepared by Service Components to test the reasonableness of the POE / BCE**
- **Independent Cost Estimate**
  - **Prepared by DOD CAIG on a DOD or Joint program for the same reason as CCA**

The Cost Estimating Process

- **Economic Analysis**
  - **A systematic approach to the problem of resource allocation**
  - **Compares two or more alternatives in terms of cost and benefits.**

The Cost Estimating Process

- **Structure of an Economic Analysis**
  - **Objectives of the action being considered**
  - **Specification of assumptions / constraints**
  - **Identification of alternatives**
  - **Listing of Benefits for all feasible alternatives**
  - **Cost estimates for each feasible alternative**

The Cost Estimating Process

- **Structure of an Economic Analysis, cont'd**
  - **A ranking of alternatives in terms of their costs and benefits**
  - **Risk / uncertainty analysis**
  - **Conclusions / recommendations**

The Cost Estimating Process

- **Analysis of Alternatives**
  - **Compare “bang for the buck” among competing alternatives**
  - **Highlights relative advantages / disadvantages**
  - **Considers sensitivity of alternatives to changes in assumptions**
  - **Used for Weapons Systems**

The Cost Estimating Process

- **Definition and Planning**
  - **Knowing the Purpose of the Estimate**
  - ***Defining the System***
  - **Ground Rules and Assumptions**
  - **Selecting the Estimating Approach**
  - **Putting the Team Together**

The Cost Estimating Process

- **Defining the System**
  - **System description provides basis on which the system cost will be estimated**
  - **Physical and performance characteristics**
  - **Development, production, deployment schedules**
  - **Cost Analysis Requirements Description (CARD)**

The Cost Estimating Process

- **Cost Analysis Requirements Description**
  - **The baseline from which the life cycle cost estimate is produced**
  - **Describes all salient features of the Acquisition Program and of the system itself**
  - **Milestone Schedule**
  - **Work Breakdown Structure (WBS)**
  - **Cost Element Structure (CES)**

The Cost Estimating Process

- **Definition and Planning**
  - **Knowing the Purpose of the Estimate**
  - **Defining the System**
  - ***Ground Rules and Assumptions***
  - **Selecting the Estimating Approach**
  - **Putting the Team Together**

The Cost Estimating Process

- **Ground Rules and Assumptions**
  - **Statements or Conditions that define where the cost estimate and results can be said to be valid**
  - **e.g., Acquisition Phase, which year dollars, whose inflation indices, etc.**
  - **Assumptions should not be arbitrary, but rather should be based on expert judgment, research and experience**

The Cost Estimating Process

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The Cost Estimating Process

- **Selecting the Estimating Approach**
  - **Grounded in historical data**
  - **Good statistics**
  - **Explainable to management**
  - **Intuitively appealing cost drivers**

Analogy Estimating Technique

- **Cost Estimating Method by which we assume our new system will behave "cost-wise" like a similar historical system**
- **Define the new system in terms of:**
  - **-- Design or Physical Parameters**
  - **-- Performance Characteristics**
  - **-- Known Similar System(s)**
- **Develop a WBS for the New and Historical System**
- **Map Historical System WBS to New System WBS so they look similar**
- **Obtain Data on Historic System's Design, Performance and Cost.**
  - **-- CY$$?**
  - **-- Learning Curve?**
  - **-- Any burdens that need to be removed?**

Analogy

- **A judgment process; requires significant experience and expertise on the part of the estimator**
  - **Determine major cost drivers**
  - **Determine characteristics of systems being compared**
  - **Assess the design/production implications of the proposed system relative to the analogous system(s)**
  - **Estimate the cost based on these design/production considerations**
  - **Generally used when there is only <u>one</u> historical program to compare the new system to.**

- **Provides a quick answer**
  - **Useful as a ballpark estimate or for validating another technique**

How to Develop an Analogy

- **Using a known item's value, apply quantified adjustments to that item which measure the differences when compared to the new.**
- **This requires good actual data and someone to quantify the differences.**
- **Recent historical data should be similar not only in performance characteristics, but also similar from the standpoint of manufacturing technology.**
- **Questions to ask when assessing the relative differences between the old and the new item:**
  - **How much different is the new compared to the old?**
  - **What portion of the old is just like the new?**
  - **How many components will be exactly the same?**
  - **What is the ratio of complexity between the two systems?**

Analogy – It's like one of these

Attribute	Old System	New System
Engine:	**F-100**	**F-200**
Thrust:	**12,000 lbs**	**16,000 lbs**
Cost:	**$5.2M**	**?**

Q: What is the unit cost of the F-200?

A: $5.2M * (16,000/12,000) = $6.9M

Tip: The mischief in analogy most often arises in the adjustment. Why do we so readily believe a linear relationship on weight which passes through the origin?

Warning 1: An adjusted analogy is like a regression, but the slope is just a guess.

Warning 2: An adjusted analogy is, by definition, estimating outside the range of the data.

Parametric Approach

- **Parameter in the sense of a “characteristic”**
  - **Cost = f(physical and performance characteristics)**

- **Estimating relationships using explanatory variables such as weight, power, speed, frequency, thrust are used to predict cost at a higher level of aggregation**
  - **Procedure consists of statistically fitting a line or function to a set of related historical data and then substituting the appropriate parameter of the new system into the resulting equation**

- **Developed from a set of sample points which realistically reflect the typical delays, problems, mistakes, redirection, and changing characteristics that occur during development of a new system**

Parametric Approach

- **Requires an extensive data base of historic cost and performance data**
- **Assumes that historic cost relationships will continue to hold true**
- **Regression analysis is the fundamental tool of parametric cost estimation**

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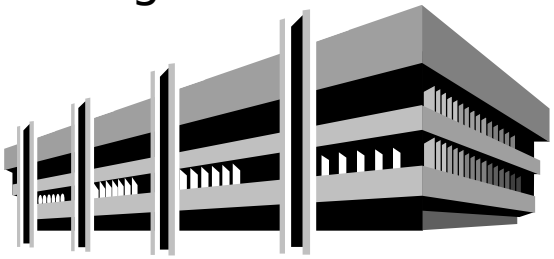
Examples of CERs

Building Construction

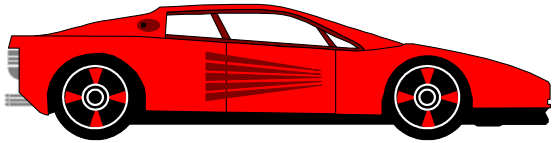


Cost is a function of:

CER VARIABLES

- Floor Space
- Numbers of Floors
- Schedule

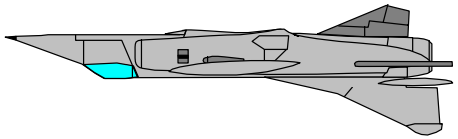
Passenger Car



Cost is a function of:

- Type, e.g., Sedan, SUV
- Doors
- Passenger Seating
- Cylinders/Horsepower

Aircraft



Cost is a function of:

- Empty Weight
- Speed
- Useful Load
- Wing Area
- Power
- Range
- Schedule

Engineering Approach

- A detailed, “bottoms-up” application of labor and material costs
- Many detailed estimates are summed together to form the total estimate
- Very data intensive, time consuming
  - Expen$ive to produce
- Increased expense not justified by significantly greater accuracy
  - Many small errors can combine to produce a large error in overall cost estimate

Extrapolation from Actuals

- For systems that have been in production for some time
- Accurate historical cost data exists
- Used after production has already begun in order to estimate the cost of continued production
- Usually needed after a major change in quantity or performance

Expert Opinion

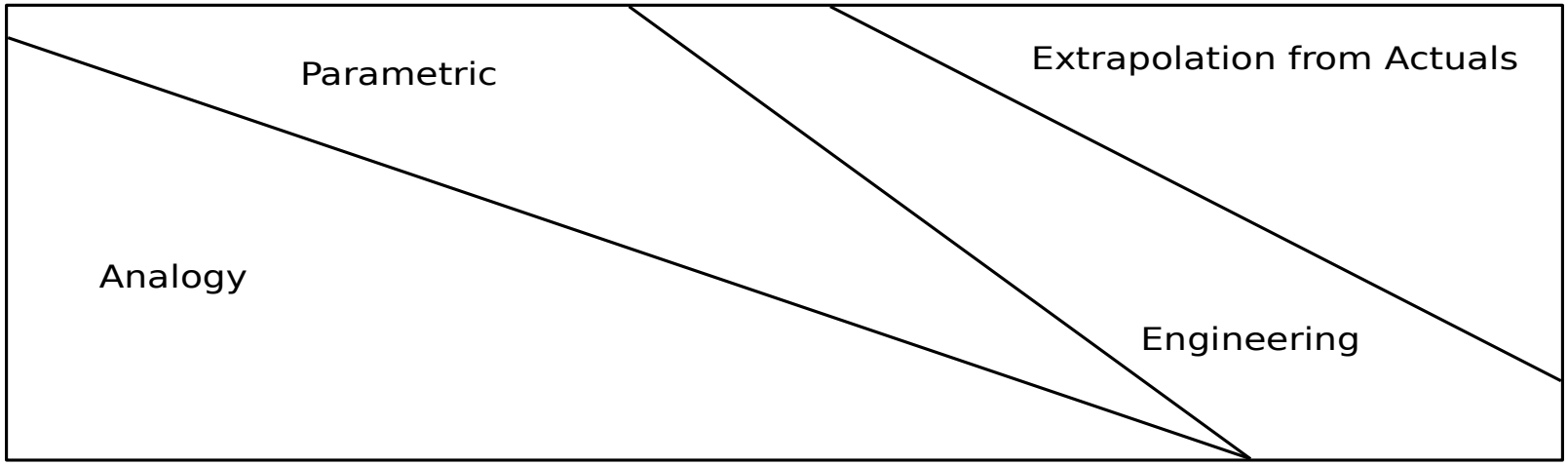
- Delphi technique, BOGSAT
  - Little, if any, analytical basis

The Cost Estimating Process

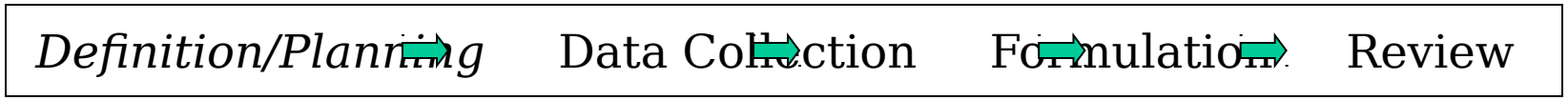
Definition/Planning ⇨ Data Collection ⇨ Formulation ⇨ Review | Docu

- **Selecting the Estimating Approach**

Concept and Technology Development	System Development and Demonstration	Production and Deployment	Operations and Support



The Cost Estimating Process



- **Definition and Planning**
  - **Knowing the Purpose of the Estimate**
  - **Defining the System**
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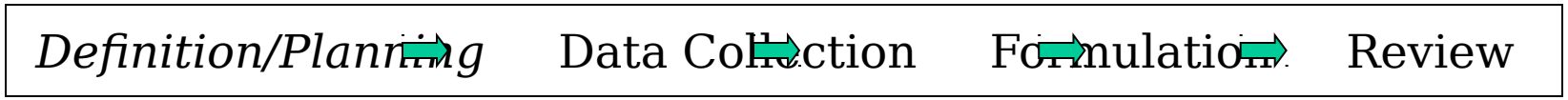
  - ***Putting the Team Together***

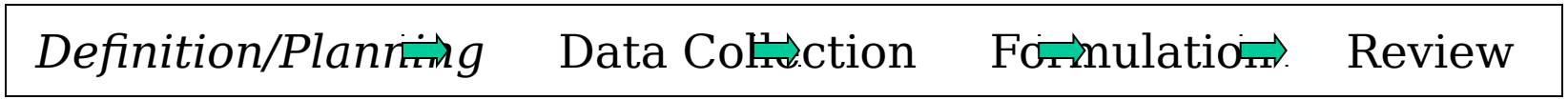
The Cost Estimating Process



- **Putting the Team Together**
  - **Cost Estimates are seldom done by one person alone**
  - **Usually need to involve:**
    - » **Engineering**
    - » **Logistics**
    - » **Contracting**
    - » **Program Management**
    - » **Etc.**

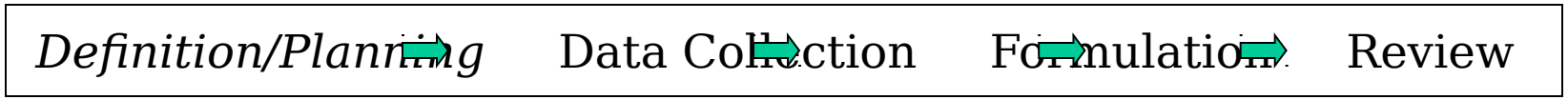
Integrated Process Team

The Cost Estimating Process



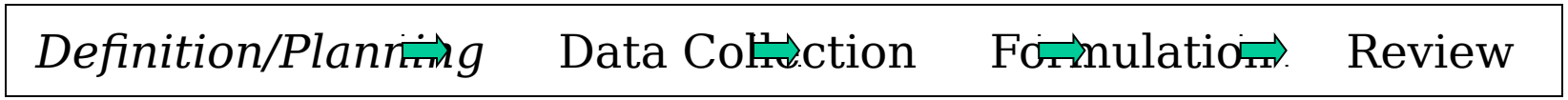
- **Data Collection and Analysis**
  - **Type of Data we collect depends on Estimating Methodology**
    - **CER: Cost Drivers, Raw Cost Data**
    - **Factor: Cost Factor Handbook, SARs, CCDRs**
    - **Analogy: Analogous Program Costs**
  - **Availability of Data may force change in estimating methodology**
  - **Must also collect technical and programmatic data**

The Cost Estimating Process



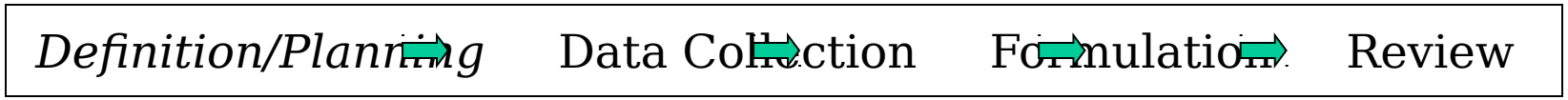
- **Estimate Formulation**
  - **Develop Factors, Analogies, CERs, Learning Curves**
  - **Aggregate Cost Elements into**
    - » **Development Costs**
    - » **Production Costs**
    - » **Operating and Support Costs**
  - **Fiscally Spread Costs**
  - **Apply Inflation**

The Cost Estimating Process



- **Review and Presentation**
  - **Ensure Estimate is**
    - » **Reasonable**
    - » **Realistic**
    - » **Complete**
  - **Cross-check with co-workers before its made public**
  - **Perform Sensitivity Analysis**
  - **Assess Risk / Uncertainty**

The Cost Estimating Process



- **Documentation**
  - **Provides a means for other analysts to reproduce our work**
  - **Must be understandable by liberal arts majors**
  - **Document Early, Document Often**

Work Breakdown Structure (WBS)

- **"A product-oriented family tree composed of hardware, software, services, data, and facilities which results from systems engineering efforts during the development and production of a defense material item."**
  - **Displays and defines the products being developed and produced**
  - **Relates the elements of work to be accomplished to each other and to the end product**

- **By displaying and defining the efforts to be accomplished, the WBS becomes a management blueprint for the product**
  - **Its relational aspects communicate management's plan for how a program is to be accomplished**

WBS Definitions

- **Program Work Breakdown Structure**
  - **The structure that encompasses an entire program at a summary level**
  - **Used by government cost estimators and contractors to develop and extend a *contract work breakdown structure***
  - **Consists of at least three levels of the program with associated definitions**
    - **Level 1: the entire material item such as an aircraft system, ship system, space system, surface vehicle system, etc.**
    - **Level 2: major elements of a material item**
    - **Level 3: element subordinate to level 2 major elements**

WBS Definitions

- **Contract Work Breakdown Structure**
  - **The government approved work breakdown structure for reporting purposes**
  - **Includes a government approved extension to lower levels by the contractor**
    - **includes all elements of products which are the responsibility of the contractor**
    - **a contract work statement provides the reporting requirements for each element to be reported which the contractor extends to the point where manageable sized increments of work are defined**

WBS Elements

- **Elements common to all types of systems:**
  - **Integration, Assembly, Test and Checkout**
  - **System Engineering/Program Management**
  - **System Test and Evaluation**
  - **Training**
  - **Data**
  - **Peculiar Support Equipment**
  - **Operational/Site Activation**
  - **Industrial Facilities**
  - **Initial Spares and Repair Parts**

Top Level Program WBS

PROGRAM WBS		
1 Aircraft System	2 Air Vehicle	3 Air Frame Propulsion Communications/ Identification Navigation/ Guidance Fire Control Automatic Flight Control Central Computer Electronic Warfare Suite Weapon Delivery Equipment Armament
	System Test and Evaluation	Development Test and Evaluation Operational Test and Evaluation Mockups Fire Control Test Facilities
	Systems Engineering/ Program Management	Systems Engineering Program Management Integrated Logistic Support
	Common Support Equipment	
	Training	Maintenance Trainers Aircrew Training Device Training Course Materials
	Data	Technical Publications Engineering Data Management Data Support Data Data Depository
	Operational/ Site Activation	Contractor Technical Support
	Initial Spares and Repair Parts	

Expanded Program WBS

PROGRAM WBS			
1 Aircraft System	2 Air Vehicle	3 Air Frame	4 Wing Fuselage Empennage Flight Control Hydraulic System Environmental Control Crew Station System Landing/ Arresting Gear System Integ, Assembly, Test, Chkout
		Propulsion Communications/ Identification	 Radio System Data Link Communications System S/ W
		Navigation/ Guidance Fire Control	 Radar Computer Controls and Displays System Software
		Automatic Flight Control Central Computer Electronic Warfare Suite Weapon Delivery Equipment Armament	
	System Test and Evaluation	Development Test and Evaluation	 Wind Tunnel Articles and Test Static Articles and Test Fatigue Articles and Test

Cost Element Structure (CES)

- **WBS equivalent for Operating and Support (O&S) Costs**
  - **Establishes a standard matrix for identifying and classifying system O&S costs**
  - **Designed to capture as many relevant O&S costs as practical**
    - » **should be tailored to meet each specific system's needs**

Generic O&S CES

- **1.0 MISSION PERSONNEL**
  - **1.1 Operations**
  - **1.2 Maintenance**
  - **1.3 Other**
- **2.0 UNIT-LEVEL CONSUMPTION**
  - **2.1 POL/ Energy Consumption**
  - **2.2 Consumable Material/ Repair Parts**
  - **2.3 Depot-Level Repairables**
  - **2.4 Training Munitions/ Expendable Stores**
  - **2.5 Other**
- **3.0 INTERMEDIATE MAINTENANCE (EXTERNAL TO UNIT)**
  - **3.1 Maintenance**
  - **3.2 Consumable Material/ Repair Parts**
  - **3.3 Other**
- **4.0 DEPOT MAINTENANCE**
  - **4.1 Overhaul/ Rework**
  - **4.2 Other**
- **5.0 Contractor Support**
  - **5.1 Interim Contractor Support**
  - **5.2 Contractor Logistics Support**
  - **5.3 Other**
- **6.0 SUSTAINING SUPPORT**
  - **6.1 Support Equipment Replacement**
  - **6.2 Modification Kit Procurement/ Installation**
  - **6.3 Other Recurring Investment**
  - **6.4 Sustaining Engineering Support**
  - **6.5 Software Maintenance Support**
  - **6.6 Simulator Operations**
  - **6.7 Other**
- **7.0 INDIRECT SUPPORT**
  - **7.1 Personnel Support**
  - **7.2 Installation Support**

CES Cost Categories

- **<u>Mission Personnel</u> includes the cost of pay and allowances of officer, enlisted, and civilian personnel required to operate, maintain, and support an operational system or deployable unit**
  - **Based on a composite rate, includes the following:**
    - **basic pay**
    - **retired pay accrual**
    - **incentive pay**
    - **special pay**
    - **basic allowance for quarters**
    - **variable housing allowance**
    - **basic allowance for subsistence**
    - **hazardous duty pay**
    - **reenlistment bonuses**
    - **family separation allowances**
    - **etc.**

CES Cost Categories

- **Unit-Level Consumption includes the following:**
  - **Cost of fuel and energy resources**
  - **Operations, maintenance and support materials consumed at the unit level**
  - **Stock fund reimbursements for depot-level repairables**
  - **Munitions expended in training**
  - **Transportation in support of deployed unit training**
  - **TAD/TDY pay**
  - **Other costs such as purchased services**

CES Cost Categories

- **<u>Intermediate Maintenance</u> includes the cost of labor and materials and other costs expended by designated activities/units in support of a primary system and associated support equipment**
  - **Calibration, repair, and replacement of parts, components or assemblies**
  - **Technical Assistance**

- **<u>Depot Maintenance</u> includes the cost of labor, material, and overhead incurred in performing major overhauls or maintenance on a defense system, its components, and associated support equipment at centralized repair depots, contractor repair facilities, or on site by depot teams.**
  - **Usually portrayed on an annual basis**

CES Cost Categories

- **Contractor Support includes the cost of contractor labor, materials, and overhead incurred in providing all or part of the logistics support to a weapon system, subsystem, or associated support equipment**

- **Sustaining Support includes the cost of replacement support equipment, modification kits, sustaining engineering, software maintenance support, simulator operations**
  - **War readiness material is specifically excluded**

- **Indirect Support includes the costs of personnel support for specialty training, permanent changes of station, medical care, base operating support and real property maintenance**

An Example Estimating Approach

1.0 Aircraft System - sum of level II elements (cross check wit
- 1.1 Air Vehicle - sum of level III elements
  - 1.1.1 Airframe - CERs
  - 1.1.2 Air Vehicle Software - Expert Opinion
  - 1.1.3 Propulsion - CERs
  - 1.1.4 Avionics - Analogy
  - 1.1.5 Armament - Catalog Price
- 1.2 System Engineering / Program Mgmt - Factor of Air Vel
- 1.3 System Test and Evaluation - Factor of Air Vehicle
- 1.4 Training - Factor of Air Vehicle
- 1.5 Data - Factor of Air Vehicle
- 1.6 Support Equipment - Factor of Air Vehicle
- 1.7 Initial Spares - Factor of Air Vehicle